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(54) **FORCE MULTIPLYING SOLENOID VALVE**

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F16K 31/06	(2006.01)
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USPC 251/129.01–1, 129.15–22; 137/556, 137/556.3
See application file for complete search history.

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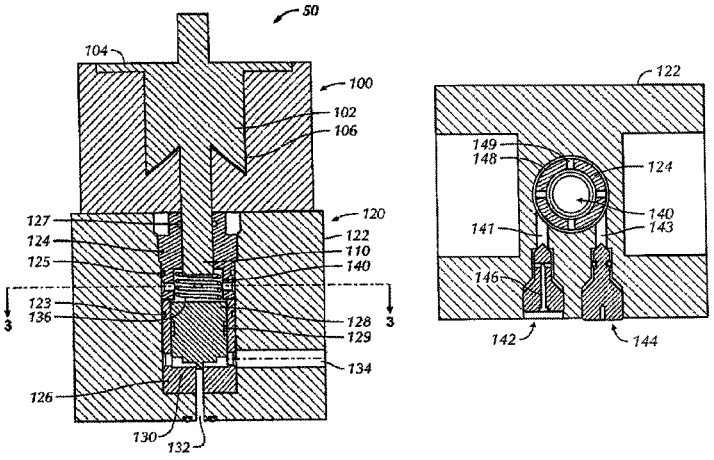
(57) **ABSTRACT**

A solenoid actuated valve assembly includes a valve body comprising a fluid inlet and fluid outlet, a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet, and a fluid chamber above the valve member, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet. The solenoid actuated valve assembly further includes a solenoid actuator coupled to the valve body comprising a solenoid plunger proximate the fluid chamber, wherein a force multiplying ratio of a surface area of the solenoid plunger exposed to the fluid chamber is at least 1.5:1.

16 Claims, 5 Drawing Sheets



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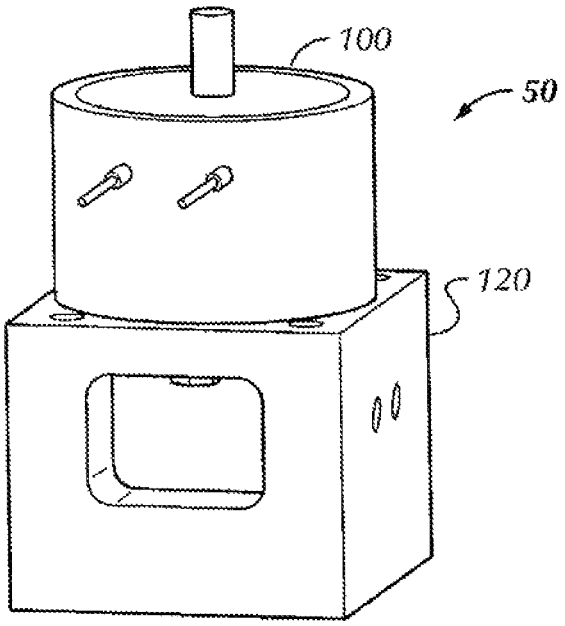

FIG. 1A

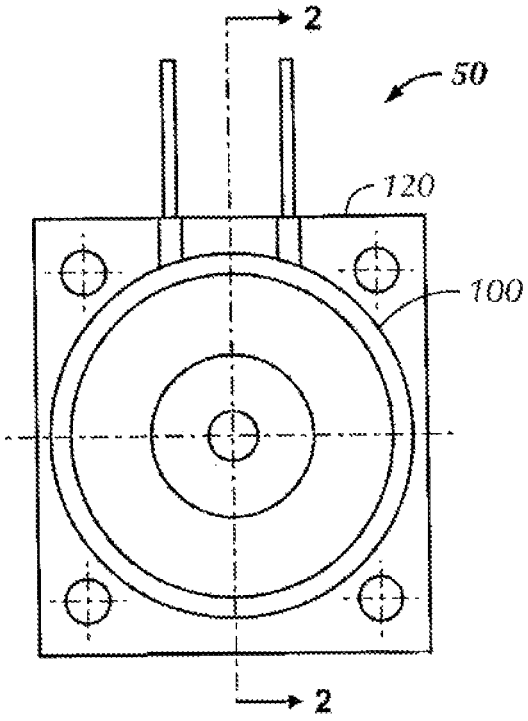

FIG. 1B

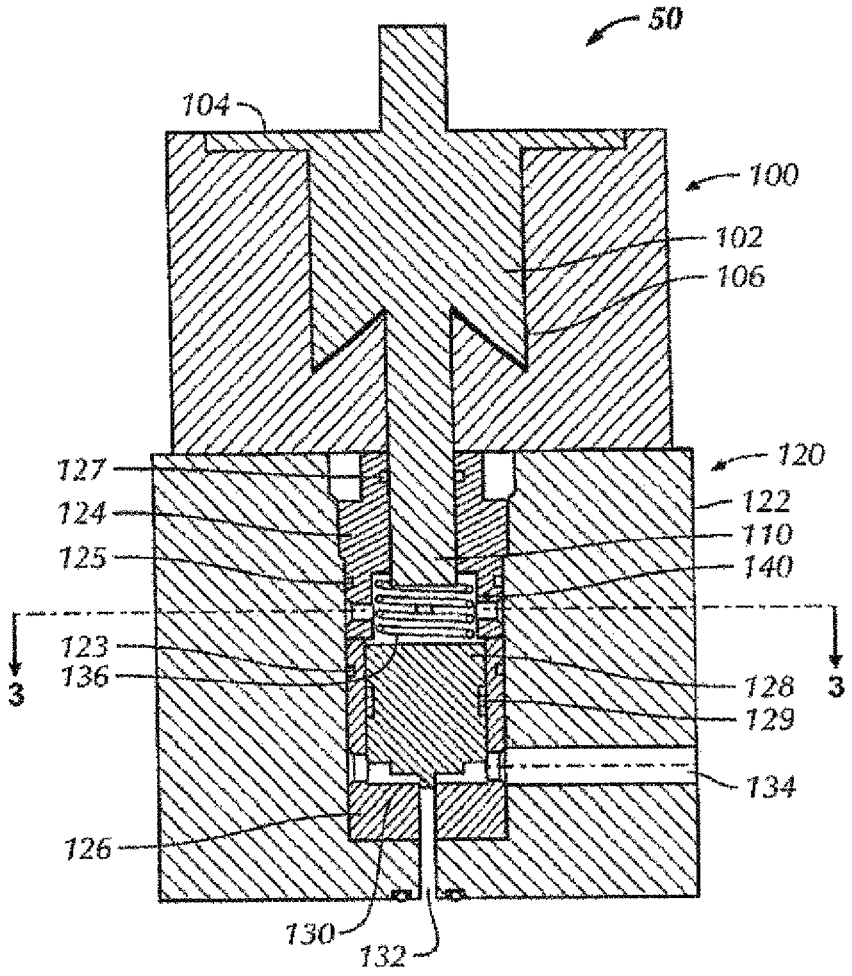
50
104
100
102
106
120
127
124
125
122
110
140
123
136
128
129
134
126
130
132
3
3

FIG. 2A

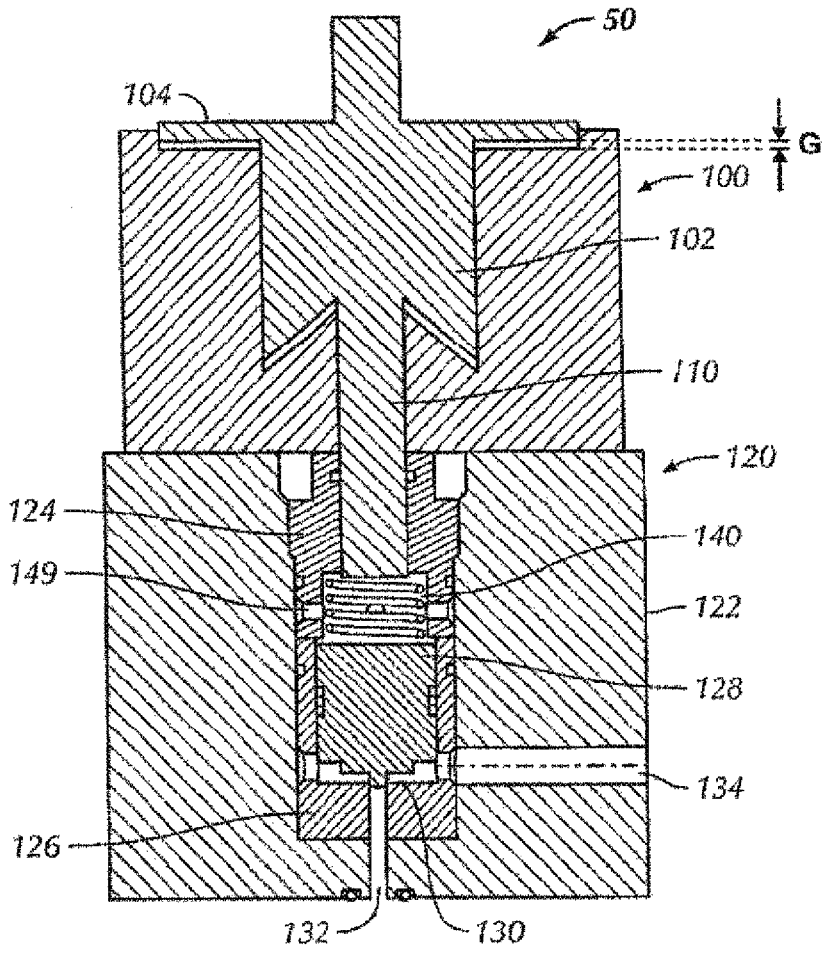

FIG. 2B

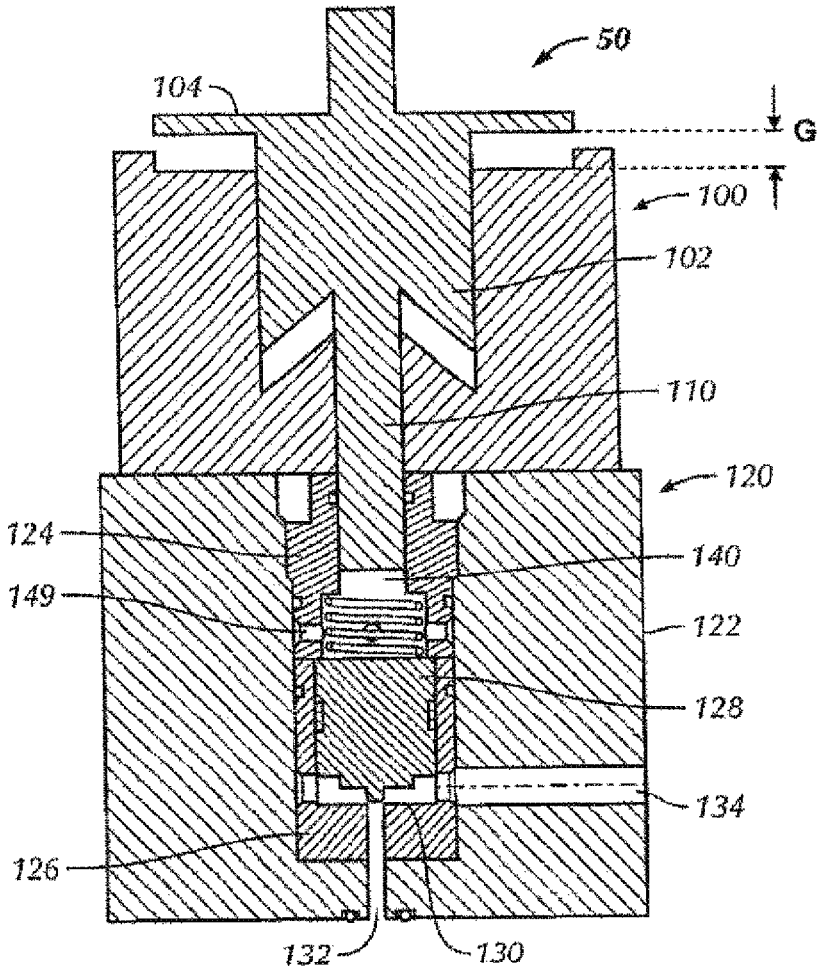

FIG. 2C

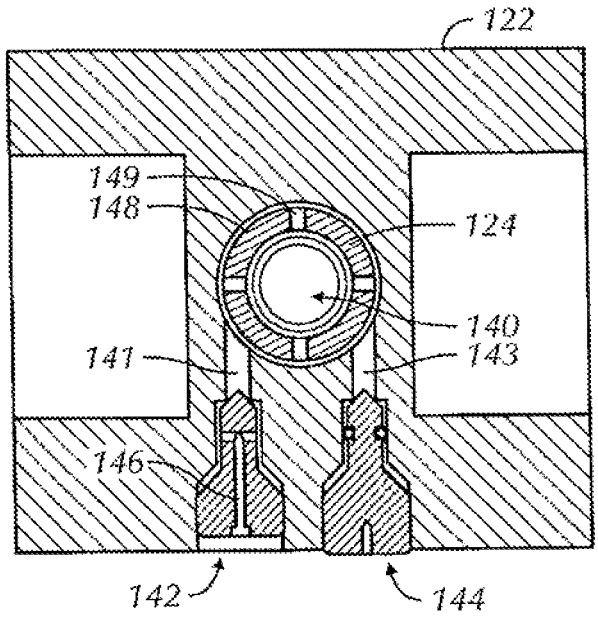
122
149
148
124
140
141
143
146
142
144

FIG. 3A

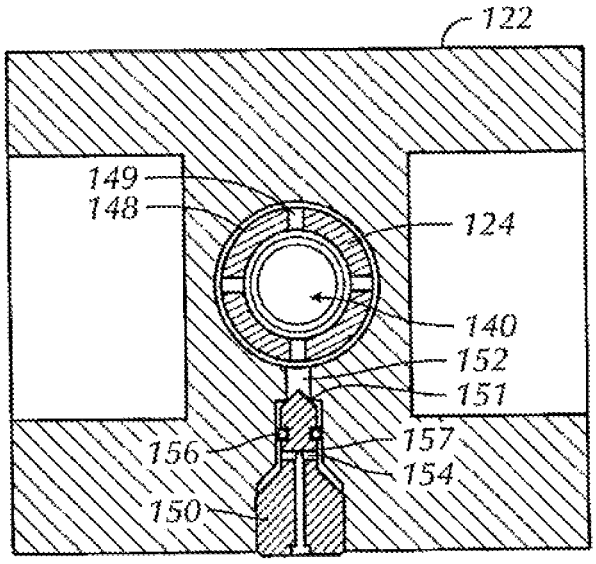
122
149
148
124
140
152
151
156
157
154
150

FIG. 3B

FORCE MULTIPLYING SOLENOID VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Stage application of International Patent Application No. PCT/US2012/022208, filed on Jan. 23, 2012, which is incorporated by reference in its entirety.

BACKGROUND

1. Field of the Disclosure

Embodiments disclosed herein relate generally to fluid control. In particular, embodiments disclosed herein relate to solenoid actuated valves and methods of use.

2. Background Art

Valves are typically used to regulate, direct, or control a fluid flow (e.g., gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Solenoid valves are typically electromechanical valves for use with liquid or gas. The solenoid valve is controlled by an electric current through a solenoid: in the case of a two-port valve the fluid flow is switched on or off; in the case of a three-port valve, the fluid flow is switched between the two outlet ports. Solenoid valves offer fast and safe switching, high reliability, long service life, lower power control, and compact design.

However, when faced with higher pressures, which produce valve imbalance loads that exceed the force produced by solenoid actuators, pneumatic or hydraulic actuators may be used to close the valve. Typically, valves with direct acting solenoid actuators may be limited to closing against pressures of 3,000 psi or less. For pressures above about 3,000 psi, systems to create additional force through mechanical leverage to aid the valve in closing may be required. However, these systems are typically complex, expensive, and may be subject to performance problems due to the harsh service environments such as in the well service industry.

Accordingly, there exists a need for a solenoid actuated valve assembly that is simple, cost-effective, and compact.

SUMMARY OF THE DISCLOSURE

In one aspect, embodiments disclosed herein relate to a solenoid actuated valve assembly including a valve body comprising a fluid inlet and fluid outlet, a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet, and a fluid chamber above the valve member, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet. The solenoid actuated valve assembly further includes a solenoid actuator coupled to the valve body comprising a solenoid plunger proximate the fluid chamber, wherein a force multiplying ratio of a surface area of the valve member exposed to the fluid chamber to a surface area of the solenoid plunger exposed to the fluid chamber is at least 1.5:1.

In other aspects, embodiments disclosed herein relate to a method for assembling a solenoid actuated valve including providing a valve comprising a fluid inlet and fluid outlet, a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet, and a fluid chamber above the valve member, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet. The method further includes providing a solenoid actuator comprising a solenoid plunger, positioning the valve member in a closed position, filling the fluid chamber with hydraulic fluid, and coupling the solenoid actuator to the valve body, wherein a stem portion of the solenoid plunger is positioned proximate the fluid chamber.

In other aspects, embodiments disclosed herein relate to a method for using a solenoid actuated valve including providing the solenoid actuated valve comprising a valve body comprising, a fluid inlet and fluid outlet, a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet, and a fluid chamber above the valve member filled with hydraulic fluid, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet, and a solenoid actuator coupled to the valve body comprising a solenoid plunger proximate the fluid chamber. The method further includes providing a multiplied force against the valve member, wherein the multiplied force corresponds with a force multiplying ratio of a surface area of the valve member exposed to the fluid chamber to a surface area of the solenoid plunger exposed to the fluid chamber.

Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A illustrates an isometric view of a solenoid actuator and valve in accordance with one or more embodiments of the present disclosure.

FIG. **1**B illustrates a top view of the solenoid actuator and valve of FIG. **1**A.

FIG. **2**A illustrates a cross-section view of the solenoid actuator and valve shown in FIG. **1**B in accordance with one or more embodiments of the present disclosure.

FIG. **2**B illustrates a cross-section view of the solenoid actuator and valve shown in FIG. **1**B in a final assembled position in accordance with one or more embodiments of the present disclosure.

FIG. **2**C illustrates a cross-section view of the solenoid actuator and valve shown in FIG. **1**B in an open position in accordance with one or more embodiments of the present disclosure.

FIG. **3**A illustrates a cross-section view of a fluid chamber of the valve shown in FIG. **2**A in accordance with one or more embodiments of the present disclosure.

FIG. **3**B illustrates a cross-section view of a fluid chamber of the valve shown in FIG. **2**A in accordance with one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

The following is directed to various exemplary embodiments of the disclosure. The embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. In addition, those having ordinary skill in the art will appreciate that the following description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to suggest that the scope of the disclosure, including the claims, is limited to that embodiment.

Certain terms are used throughout the following description and claims refer to particular features or components. As those having ordinary skill in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but not function. The figures are not necessarily to scale. Certain features and components herein may be shown exaggerated in

scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.

In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . . " Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. Thus, if a first component is coupled to a second component, that connection may be through a direct connection, or through an indirect connection via other components, devices, and connections. Further, the terms "axial" and "axially" generally mean along or parallel to a central or longitudinal axis, while the terms "radial" and "radially" generally mean perpendicular to a central longitudinal axis.

In one aspect, embodiments disclosed herein relate to force multiplying solenoid actuated valves **50** having a solenoid actuator **100** coupled to a valve **120** shown in FIGS. **1**A and **1**B and related methods of use. Referring to FIG. **2**A, a cross-section view of a solenoid actuated valve assembly **50** in accordance with one or more embodiments of the present disclosure is shown. The valve assembly **50** includes a solenoid **100** in which a solenoid plunger **102** is disposed. The solenoid **100** may be an electromagnetic solenoid including an electromagnetically inductive coil (not shown) wound around a movable steel structure, or armature **106**. As will be understood by one or ordinary skill in the art, the coil may be shaped such that the armature **106** (and the solenoid plunger **102**) may be moved in and out of the solenoid **100**. The solenoid **100** further includes a visual position indicator **104** disposed on an outer end of the solenoid plunger **102**. The visual position indicator **104** may include a flat shoulder which also acts a stop against an outer surface of the solenoid **100**. The visual indicator **104** is used to indicate whether the valve is open or closed, as will be described in more detail below.

The solenoid actuated valve assembly **50** further includes a valve **120** having a valve body **122** to which the solenoid **100** may be coupled. The solenoid **100** may be coupled to the valve body **122** with mechanical fasteners (not shown) (e.g., bolts or studs with nuts). The valve body **122** has a high pressure inlet port **132** connected to an inlet flowline (not shown) and a low pressure outlet port **134** connected to an outlet flowline (not shown) formed therein. In addition, a substantially cylindrical valve member **128** is disposed within a bore in the valve body **122**. A position of the valve member **128** controls the fluid flow from the inlet port **132** through the valve body **122** to the outlet port **134**.

The valve member **128** slides within a lower cage **126** in the valve body **122**. The lower cage **126** may be free-floating within the valve body **122** or attached (e.g., screwed in or welded to the valve body **122**). The lower cage **126** has a valve seat **130** formed in a lower surface against, which the valve member **128** seats. The bottom of the valve member **128** is forced down against the valve seat **130** when the valve **120** is closed to prevent fluid communication between the inlet port **132** and the outlet port **134**. Alternatively, in other embodiments, the bottom of the valve member **128** may be forced down against a valve seat formed directly in the valve body **122** (with no lower cage installed). Seals **123** located between the lower cage **126** and wall of the valve body **122**, and seals **129** located between the lower cage **126** and the valve member **128** isolate a volume above the valve seat **130** and the outlet port **134** and below the valve member **128** from a fluid chamber **140** located above the valve member **128**.

The fluid chamber **140** is located above the valve member **128** and below a stem portion **110** of the solenoid plunger **102**. The stem portion **110** of the solenoid plunger **102** extends through an upper cage **124** disposed in the valve body **122** (i.e., typically screwed in) above the fluid chamber **140**. Seals **127** located between the stem portion **110** and the upper cage **124** prevent fluid loss therebetween. In addition, the fluid chamber **140** is sealed by seals **125** between the upper cage **124** and the valve body **122**, in addition to seals **123** and **129** previously described.

In certain embodiments, a spring **136** or other biasing mechanism may be disposed within the fluid chamber **140** to bias the valve member **128** to a closed position (i.e., to bias a bottom of the valve member **128** into contact with the valve seat **130**) when the valve **120** is not in use. For example, the spring may be a coil, Belleville, or other type of spring known to those skilled in the art. In certain embodiments the spring **136** may provide a force of between about 1 and 5 pounds against the valve member **128**.

Referring now to FIG. **3**A, a cross-section view of the fluid chamber **140** in accordance with one or more embodiments of the present disclosure is shown. The fluid chamber **140** may be filled with an incompressible fluid (e.g., hydraulic fluid) through a bore in the upper cage **124** prior to coupling the solenoid **100** to the valve body **122**. In other embodiments, the fluid chamber **140** may be filled with hydraulic fluid through a first port **141** in which a bleed screw **142** is installed, or a second port **143** in which a solenoid adjustment screw **144** is installed. Hydraulic fluid reaches the fluid chamber **140** through the first and second ports **141** and **143**, which communicate with one or more orifices **149** of the upper cage **124** and disposed adjacent an annular recess **148** formed in the valve body **122**.

The bleed screw **142** has a bleed channel **146** formed therein through which fluid may flow out from the fluid chamber **140** when the bleed screw **142** is unseated. The solenoid adjustment screw **144** is used to adjust the travel of the solenoid plunger **102** and prevent the solenoid plunger **102** from contacting the solenoid **100** when the valve **120** is closed. In certain embodiments, the solenoid adjustment screw **144** may include a lock nut (not shown) or other locking device that is tightened after the solenoid adjustment screw **144** is fully seated. Operation of the bleed screw **142** and solenoid adjustment screw **144** is described in detail below.

To relieve fluid from the fluid chamber **140**, both the bleed screw **142** and solenoid adjustment screw **144** may be turned outward one or two turns off their seated positions in the first and second ports **141** and **143**. While one or two turns are given as an example, those skilled in the art will appreciate that any number of turns may be used to unseat the solenoid adjustment and bleed screws. While setting the bleed and solenoid adjustment screws, the valve member **128** remains in contact with the valve seat **130** in the lower cage **126** (i.e., in a closed position). The bleed screw **142** allows excess hydraulic fluid to escape from the fluid chamber **140** as the stem portion **110** of the solenoid plunger **102** is moved toward the fluid chamber **140** and displaces hydraulic fluid (which occurs when the solenoid **100** is coupled to the valve body **122**. Once the visual indicator **104** of the solenoid plunger **102** is positioned on top of the solenoid **100**, and any excess hydraulic fluid has escaped from the fluid chamber **140**, the bleed screw **142** may be returned to a fully seated position by turning the bleed screw **142** back in to the first port **141**. The fully seated bleed screw **142** locks the hydraulic fluid in the fluid chamber **140**.

After the bleed screw **142** is returned to a fully seated position, the solenoid adjustment screw **144** may also be returned to a fully seated position (i.e., turned inward to seat) to set the travel of the solenoid plunger **102**. Moving the

solenoid adjustment screw **144** inward to a seated position displaces hydraulic fluid in the second port **143** back against the stem portion **110** of the solenoid plunger **102**, causing the solenoid plunger **102** to move upward and move the visual position indicator **104** slightly off (illustrated by gap "G") the solenoid **100**, as shown in FIG. **2**B.

Fully seating the solenoid adjustment screw **144** and lifting the visual indicator **104** off the solenoid **100** by a certain amount (gap G) provides an indication that the solenoid plunger **102** is appropriately adjusted. Properly adjusted, the visual indicator **104** will not contact the solenoid **102** (or "bottom out"), thus preventing the solenoid **102** from losing effectiveness in applying force against the valve member **128** in a closed position. In certain embodiments, the visual position indicator **104** may be moved between 0.015 and 0.045 of an inch off the solenoid **100**. In other embodiments, the distance G may be about 0.030 of an inch.

Referring briefly to FIG. **3**B, other embodiments disclosed herein may include a solenoid adjustment/bleed screw **150** which incorporates both features of a bleed screw and a solenoid adjustment screw. The solenoid adjustment/bleed screw **150** is installed in a single port **152** in fluid communication with the fluid chamber **140**. The solenoid adjustment/bleed screw **150** has a bleed channel **154** formed therein and, in addition, an O-ring located ahead of the bleed channel **154**. Fluid may flow from the fluid chamber **140** through the bleed channel **154** when the adjustment/bleed screw **150** is positioned such that it is out of contact from seat **151** (i.e., unseated) and the O-ring **156** is not engaged in bore **157**.

In one example, the solenoid adjustment/bleed screw **150** may be turned outward four turns and unseated from seat **151**, which moves the O-ring **156** out of contact with bore **157** in port **152** to allow fluid to escape through the bleed channel **154** from the fluid chamber **140**. Once excess hydraulic fluid is removed from the fluid chamber **140**, the solenoid adjustment/bleed screw **150** may then be turned inward two turns, which moves O-ring **156** back into sealing contact with bore **157** in port **152** so that hydraulic fluid is locked in the fluid chamber **140**. Finally, the solenoid adjustment/bleed screw **150** may be turned in an additional two turns to fully seat the solenoid adjustment/bleed screw **150** on the seat **151**. The fully seated solenoid adjustment/bleed screw **150** displaces hydraulic fluid in the fluid chamber **140** to move the visual indicator **104** (FIG. **2**B) off the solenoid **100**. Those skilled in the art will appreciate that the number of turns of the solenoid adjustment/bleed screw **150** may be varied and still accomplish both the bleed and solenoid adjustment functions.

Once the hydraulic fluid is locked within the fluid chamber **140**, force provided by the solenoid **100** may be transferred through the hydraulic fluid and multiplied against a surface of the valve member **128** exposed to the fluid chamber **140**. The force multiplication is accomplished by the surface area differences between the stem portion **110** of the solenoid plunger **102** and the valve member **128**. As shown in FIG. **2**A, the valve member **128** has a surface area exposed to the fluid chamber **140** that is larger than a surface area of the stem portion **110** exposed to the fluid chamber **140**. Therefore, a force multiplying effect is created between the stem portion **110** of the solenoid plunger **102** and the valve member **128** surfaces exposed to the fluid chamber **140**.

For example, in one embodiment, a surface area of the stem portion **110** exposed to the fluid chamber **140** may be one-fourth a surface area of the valve member **128** exposed to the fluid chamber, which provides a 4:1 force multiplying ratio between the surfaces. With a 4:1 force multiplying ratio, a force generated by the solenoid actuator **100** provides a force that is approximately 4 times greater between the valve member **128** and the valve seat **130**. While a 4:1 force multiplying ratio is illustrated as an example, one of ordinary skill in the art will appreciate that other force multiplying ratios between surface areas of the stem portion **110** and the valve member **128** exposed to the fluid chamber **140** may be used depending on the application and the force multiplying effect desired. For example, a 2:1 force multiplying ratio or greater may be used in accordance with one or more embodiments disclosed herein. In other embodiments, a 1.25:1 force multiplying ratio or greater may be used.

Methods of assembling the solenoid actuated valve assembly **50** are described in reference to FIGS. **2**A-**2**C in accordance with one or more embodiments of the present disclosure. Initially, the valve member **128** is maintained in the closed position against the valve seat **130** while filling the fluid chamber **140** with hydraulic fluid. The fluid chamber **140** is filled with hydraulic fluid through a bare in the upper cage **124** and the solenoid **100** is that coupled to the valve body **122**.

The bleed screw **142** and solenoid adjustment screw **144** are unseated (e.g., turned outward) as the solenoid **100** is coupled to the valve body **122** to allow excess hydraulic fluid in the fluid chamber **140** to be relieved through the bleed screw **142** (FIG. **3**A). The visual indicator **104** will sit flush on the solenoid **100** when all excess hydraulic fluid is out. The bleed screw **142** is then turned inward and returned to a fully seated position to lock hydraulic fluid in the fluid chamber **140**. After the bleed screw **142** is fully seated, the solenoid adjustment screw **144** is turned inward to a fully seated position, which causes the visual indicator **104** to lift off the solenoid **100** a distance G (FIG. **2**B) due to displacement of the hydraulic fluid locked in the fluid chamber **140**. FIG. **2**B represents the solenoid actuated valve assembly **50** in a final position after assembly.

Once assembled, the solenoid **100** may be energized to cause the solenoid plunger **102** to provide a force against the hydraulic fluid in the fluid chamber **140**. The force is transferred through the hydraulic fluid in the fluid chamber **140** and against the valve member **128**. The force applied against the valve member **128** is multiplied according to the force multiplying ratio provided between surface areas of the solenoid plunger **102** and valve member **128** exposed to the fluid chamber **140**. As long as the solenoid **100** is energized, the valve member **128** will remain seated against the valve seat **130** and inlet port **132** will remain closed to prevent fluid communication between the fluid inlet **132** and outlet **134**. In certain embodiments, the solenoid actuated valve assembly **50** may be closed against fluid pressures present in the inlet port **132** of up to 20,000 psi.

To open the valve, as shown in FIG. **2**C, the solenoid **100** may be de-energized. With no downward force provided from the solenoid **100**, the pressure in the inlet port **132** forces the valve member **128** upward to allow fluid flow from the inlet port **132** to the outlet port **134**. The solenoid plunger **102**, in turn, is forced upward by a distance which corresponds to the force multiplying ratio. For example, for a 4:1 force multiplying ratio, the solenoid plunger **102** is forced upward by a distances that is four times greater than the travel of the valve member **128** in the lower cage **126**. Upward movement of the visual indicator **104** gives a positive indication that the valve **120** is open. The valve **120** may be opened and closed by alternately energizing and de-energizing the solenoid **100**.

Advantageously, embodiments of the present disclosure provide a compact solenoid actuated valve assembly that is capable of closing against very high fluid pressure without requiring larger, more complex pneumatic or hydraulic actuator systems. Overall, the size, weight, and complexity of the

solenoid actuated valve is reduced and requires less assembly time. Further, because the volume of hydraulic fluid in the fluid chamber of the valve, rather than its pressure, retains the valve in a closed position, a high pressure fluid source is not required to operate the valve. Thus, response time of the valve is reduced because a high volume of fluid is no longer required to operate the actuator.

In addition, due to the force multiplying ratios provided between the valve member and the solenoid plunger, the valve itself does not need to generate sufficient force to counterbalance high pressures present in the fluid inlet. Therefore, the valve member can be relatively small and compact. Moreover, costs to the end user are decreased due to the simplicity of the actuator and because no separate pneumatic or hydraulic supply lines are required to operate the valve. Overall, the one or more embodiments disclosed herein provide a more compact, less expensive, more reliable solenoid actuated valve assembly capable of operating against pressures of up to about 20,000 psi, or higher.

While the present disclosure has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments may be devised which do not depart from the scope of the disclosure as described herein. Accordingly, the scope of the disclosure should be limited only by the attached claims.

What is claimed is:

1. A solenoid actuated valve assembly comprising:
a valve body comprising:
a fluid inlet and fluid outlet;
a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet;
a fluid chamber above the valve member, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet;
a bleed screw disposed in a first port in fluid communication with the fluid chamber, wherein the bleed screw includes a bleed channel therethrough;
a solenoid adjustment screw disposed in a second port in fluid communication with the fluid chamber; and
a solenoid actuator coupled to the valve body comprising:
a solenoid plunger proximate the fluid chamber;
wherein a force multiplying ratio of a surface area of the valve member exposed to the fluid chamber to a surface area of the solenoid plunger exposed to the fluid chamber is at least 1.5:1.

2. The solenoid actuated valve assembly of claim **1**, further comprising a lower cage disposed in the valve body in which the valve member slides.

3. The solenoid actuated valve assembly of claim **2**, wherein the lower cage comprises a valve seat that contacts the valve member.

4. The solenoid actuated valve assembly of claim **1**, further comprising an upper cage positioned above the fluid chamber.

5. The solenoid actuated valve assembly of claim **4**, wherein the upper cage comprises one or more ports spaced around a circumference thereof and positioned adjacent an annular groove of the valve body.

6. The solenoid actuated valve assembly of claim **1**, further comprising:
a visual indicator on an end of the solenoid plunger,
wherein the solenoid adjustment screw is configured to set the visual indicator at a distance off the solenoid actuator of between about 0.015 and 0.045 of an inch.

7. The solenoid actuated valve assembly of claim **1**, wherein the solenoid adjustment screw further comprises an O-ring.

8. The solenoid actuated valve assembly of claim **1**, further comprising a valve seat in the valve body which contacts the valve member.

9. The solenoid actuated valve assembly of claim **1**, further comprising a spring in the fluid chamber which biases the valve member in a first direction.

10. The solenoid actuated valve assembly of claim **1**, further comprising:
a visual indicator on an end of the solenoid plunger,
wherein the solenoid adjustment screw is configured to set the visual indicator at a distance off the solenoid actuator greater than 0.015 of an inch.

11. A method for assembling a solenoid actuated valve, the method comprising:
providing a valve comprising:
a fluid inlet and fluid outlet;
a valve member disposed within a valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet; and
a fluid chamber above the valve member, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet;
providing a solenoid actuator comprising:
a solenoid plunger;
positioning the valve member in a dosed position;
filling the fluid chamber with hydraulic fluid;
coupling the solenoid actuator to the valve body, wherein a stem portion of the solenoid plunger is positioned proximate the fluid chamber;
relieving excess hydraulic fluid from the fluid chamber through a bleed screw port in the valve body; and
adjusting a position of the solenoid plunger with a solenoid adjustment screw.

12. The method of claim **11**, further comprising positioning a visual indicator on an end of the solenoid plunger at a distance of between about 0.015 and 0.045 of an inch off the solenoid actuator.

13. The method of claim **11**, further comprising positioning a visual indicator on an end of the solenoid plunger at a distance greater than 0.015 of an inch off the solenoid actuator.

14. A method for using a solenoid actuated valve, the method comprising:
providing the solenoid actuated valve comprising:
a valve body comprising:
a fluid inlet and fluid outlet;
a valve member disposed within the valve body, wherein a position of the valve member controls a fluid flow between the fluid inlet and fluid outlet; and
a fluid chamber above the valve member filled with hydraulic fluid, wherein the fluid chamber is fluidly isolated from the fluid inlet and outlet; and
a solenoid actuator coupled to the valve, body comprising:
a solenoid plunger proximate the fluid chamber;
relieving excess hydraulic fluid from the fluid chamber through a bleed screw port in the valve body; and
providing a multiplied force against the valve member,
wherein the multiplied force corresponds with a force multiplying ratio of as surface area of the valve member exposed to the fluid chamber to a surface area of the solenoid plunger exposed to the fluid chamber.

15. The method of claim **14**, wherein the force multiplying ratio is at least 1.5:1.

16. The method of claim 14, wherein providing a multiplied force further comprises energizing the solenoid actuator.

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